# FIELD TESTING PESTICIDE TRANSPORT MODELS AT A COOPERATIVE TEST SITE NEAR PLAINS, GEORGIA

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## INTRODUCTION

Leaching of pesticides is a potential problem in the major agricultural production areas of southern Georgia where sandy soils are predominant. Compounds used on crops such as peanuts, corn, and soybeans are of particular interest because of their potential to leach under certain conditions. Several models that simulate transport and transformation of pesticides in the environment have been developed; these include: RUSTIC (Dean et al., 1989), GLEAMS (Leonard, et al., 1987), AGG (Fong and Mulkey, 1990), and LEACHM (Wagenet and Hutson, 1989). These or other models can be useful for making management decisions pertaining to chemical use. Effective use of such models is dependent on how well these models perform in field situations.

Field data are necessary for evaluating factors that affect the leaching process. Such data are required for testing model predictive capability. A field study to provide a database for model testing was initiated in 1988 at a site near Plains, GA. The study site is in the Fall Line Hills district of the Coastal Plain province. The Claiborne aquifer recharge area is located in this district.

The U. S. Environmental Protection Agency, the U. S. Department of Agriculture, the U. S. Geological Survey, and the University of Georgia Agricultural Experiment Station developed a joint research effort to investigate and to model pesticide movement at the Plains site. The study was planned for 5 years duration, beginning with the 1989 cropping season. As early as 1986, the USDA and USGS were involved in characterization studies at this site. The participants are sharing technical expertise and resources to develop a better understanding of physical, chemical, and biological processes that affect leaching, to evaluate spatial and temporal variability, and to develop and test linked models for chemical transport and transformation. One product of this cooperative research effort will be a comprehensive database that should be useful for testing such models. The study design is amenable to implementing the testing methodology proposed by Parrish and Smith (1990), as well as other techniques.

This paper describes the field design and presents preliminary pesticide leaching results obtained for the first year of the study.

## DESCRIPTION OF THE STUDY

The field site is a 0.81 ha rectangular area of approximately 91m × 91m, which provides 100 rows of corn when spaced at 0.91 m on centers. For design purposes, the plot was subdivided into four equal-sized quadrants (Figure 1). The site had a slope of less than 1% (estimated). Surface runoff occurs toward the southwest corner of the plot. A soil berm was constructed around the perimeter of the plot to control runoff. An H-flume (0.46m) was installed at the southwest corner of the plot to measure sediment and chemical transport in runoff (Smith, et al., 1985). A stage recorder and an automated stage-activated runoff-sample collector was installed. Soil at the site was classified as Eustis by the USDA Soil Conservation Service and is a well-drained sand of hydrologic group A (Asmussen, 1990).

Conventional agricultural management practices were used for tillage, fertilization, planting, and chemical application. Three pesticides and a bromide tracer were applied in 1989 and were monitored for their downward movement. Chemical applications were monitored directly and soil core samples were collected at various times after application, as described below. A center-pivot irrigation system was installed on the site, supplied from a deep well located approximately 300 m west of the site. The general groundwater flow is from north to south. Irrigation water was applied to the site after chemical application and planting and, also, as required during the growing season to supplement natural rainfall.

During 1988, wells and soil solution samplers (suction lysimeters) were installed at various locations within the site on crop row centers for the purpose of monitoring concentrations of pesticides and bromide. As shown in Figure 1, 12 permanent monitoring sites were located randomly (3 per quadrant). Each of these consisted of three 5-cm-diameter wells screened individually at three depth increments corresponding to the top, middle, and lower zones of the Claiborne aquifer, and one 5-cm fully penetrating well. Also, at eight of the 12 sites, seven soil solution samplers were installed at depths ranging from 0.6m to 4.3m in 0.6m increments. These samplers were used to provide information on maximum depths of leaching. Concentrations derived from soil-core samples are to be used for evaluating model performance.

Liquid forms of atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5 triazine), carbofuran (2,3 dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate), and alachlor (2-chloro-2'6'-diethyl-N-(methoxymethyl)-acetanilide) were applied individually at label-recommended rates immediately following planting. Potassium bromide salt, in liquid form, was applied as a conservative tracer following the pesticide application. A conventional tractor-mounted spray rig was used, having six #8003 nozzles on 30-cm centers, which provided lateral coverage of 1.8 m (across two crop rows). With the exception of carbofuran, actual application rates were monitored by the use of filter disks located randomly within the field, as described in Smith, et al., 1985. The filter disks were positioned so as to intercept the pesticide spray; they were collected immediately after being sprayed and were shipped to a laboratory for analysis. Target rates for atrazine, alachlor, carbofuran, and bromide were, respectively, 2.24, 2.80, 2.24, and 112 kg $ha^{-1}$. The carbofuran application rate was not monitored with filter disks due to the risk of worker exposure to this compound during post-application collection.

Immediately following the chemical applications, 1.3 cm of irrigation water was applied. This induced the compounds to move below the immediate surface layer.

Background samples collected prior to initiation of the study did not reveal any traces of the test compounds. On each of several dates after application, soil cores were obtained at 12 to 20 random locations on row centers within the field to varying depths, depending on the anticipated depth of leaching. Samples were obtained from as many as 27 depths ranging to 9.1m, spaced as follows: every 0.15 m down to a depth of 1.8 m, every 0.30 m down to 4.6 m, and every 0.8 m down to 9.1 m. Hand augers were used for collection of samples down to 2 m during the growing season, and a drill rig equiped with a continuous-coring device (CME hollow-stem split-tube bearing-head sampler with 15-cm liners) was used to collect soil cores from deeper zones prior to application and after harvest. The timing of the sampling events was determined on the basis of rainfall quantity and expected degradation rates. For 1989, samples were collected at 2, 9, 27, 49, 91, and 119 days after application.

Precipitation data were recorded at 5-minute intervals at four local sites. Pan evaporation, wind speed, wind direction, ambient air temperature, and rainfall (long-term) data were collected at a site adjacent to the plot and also at the University of Georgia Plains Experiment Station located 5 km from the site.

## SUMMARY

For atrazine and alachlor, the application rate as measured by filter disks differed from calculations based on the actual total mass of compound applied to the field. Measured application rates for atrazine and alachlor were, respectively, $1.90 \pm 0.023$ and $1.70 \pm 0.018$ kg $ha^{-1}$, based on sample sizes of 87 and 100. The differences amounted to a 15% loss for atrazine and 39% for alachlor in separate applications. It is believed that the losses are due jointly to drift and volatilization. Results for bromide are not yet available. In a previous study (Smith and Parrish, 1990), metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide] applied in a similar manner exhibited losses on the order of 26%.

All compounds were monitored on 2, 9, 27, 49, 91, and 119 days after application. On sampling days 2 through 91, soil cores were obtained at 20 randomly located sites; on day 119, 20 sites were sampled down to 1.5 m, and at 12 of those sites, samples were obtained down to 9.1 m. Figures 2-4 show concentration profiles for alachlor, atrazine, and carbofuran, respectively. For alachlor, maximum depth of pesticide movement was to the 15 to 30 cm depth increment, and very little measurable residue remained on day 27. Atrazine exhibited more persistence and deeper movement. After 2 days, atrazine was detected at the 76 to 91 cm depth, with a maximum leaching depth observed on day 49 of 152 to 168 cm. The profile has a general J-shaped appearance except for day 27 where a peak is observed at the 15 to 30 cm depth. Carbofuran showed a similar J-shape on day 2 but quickly developed a definitive peak that appeared to move down progressively. On day 119, carbofuran was observed at low levels as deep as 3 m. This was the only pesticide that persisted at measurable levels for the entire sampling period.

Transformation rates with depth are difficult to measure in the field due to the fact that pesticide transport and transformation are occurring simultaneously. By combining measurements at all depths at different times after application, the total mass of a compound that remains in the soil column can be estimated (see Figures 2-4). These values can be used to derive a profile-averaged half-life.

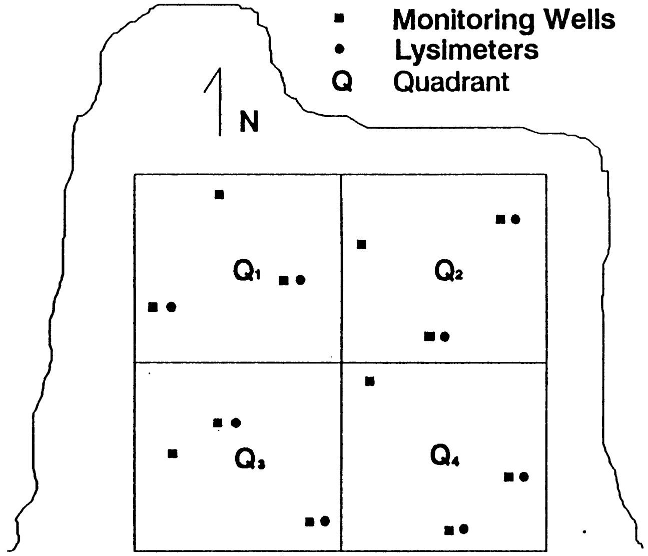


Figure 1. Field monitoring sites, Plains 1989

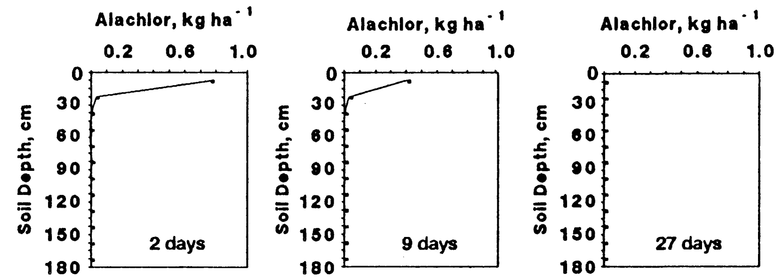


Figure 2. Alachlor in soil profile over sampling period

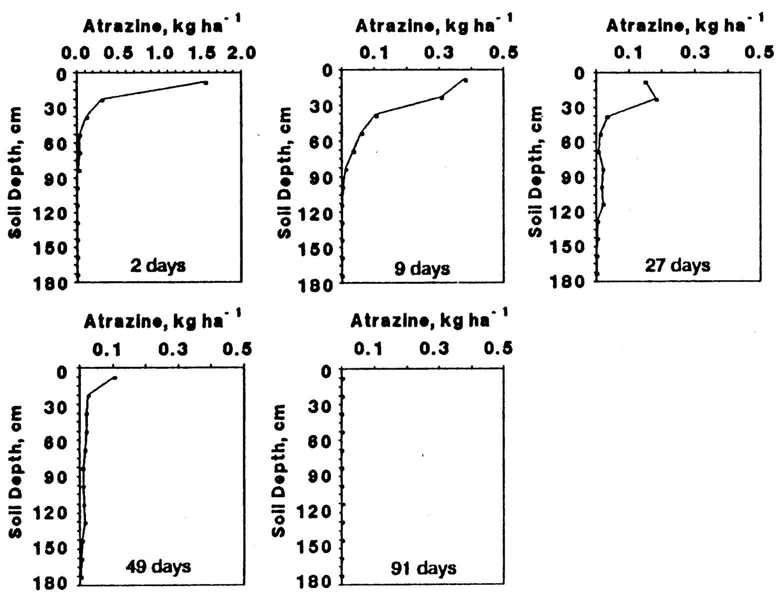


Figure 3. Atrazine in soil profile over sampling period

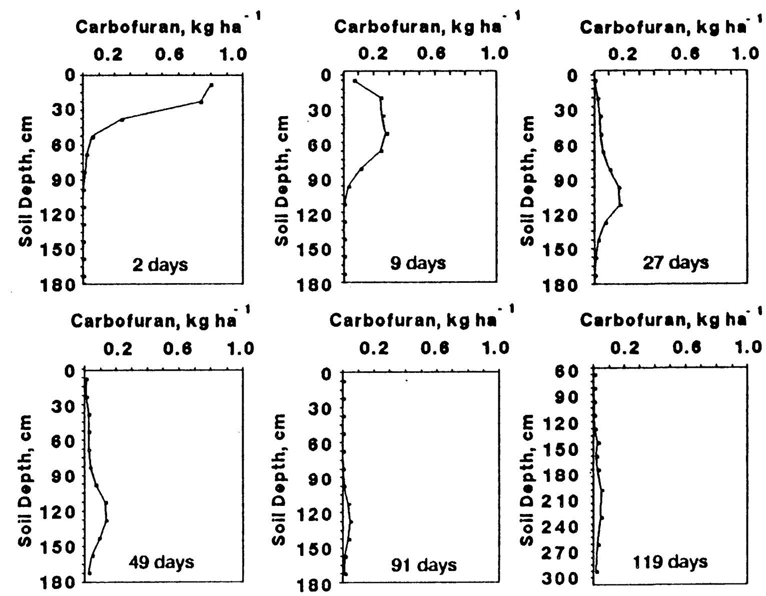


Figure 4. Carbofuran in soil profile over sampling period

For atrazine, the observed half-life was 14.2 days; for alachlor, it was 2.6 days; and for carbofuran, it was 26.5 days. Previous studies (Smith et al., 1990; Rao et al., 1986) have revealed that transformation rates decrease with increasing depth for metolachlor and aldicarb [2-methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl) oxime]. A profile-averaged half-life measures a rate that actually varies within the profile, and it is believed that rates are higher in the upper zones.

The database being developed for the Plains, Georgia site can be used for testing a variety of models, including RUSTIC (Dean, et al., 1989) which includes linked components corresponding to the root zone, the vadose zone, and the saturated zone. A primary objective for EPA-Athens staff is to test the predictive capability of RUSTIC, a project which currently is in progress. Initial testing will include comparisons between observed and predicted results for the three pesticides for the 1989 cropping season. Results will be evaluated using the quantitative testing methodology proposed by Parrish and Smith (1990). Input parameter sets for RUSTIC are being derived from several sources including site-specific data, the RUSTIC user manual, and the DBAPE soils database (Imhoff, et al., 1990).

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